Server

Scanner

ICT FUNDAMENTAL THEORY

Computer chips

Monitor

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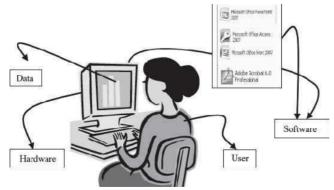
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INTRODUCTION TO COMPUTER

Computer is an electronic device that input, process, store and output data/ information that is useful to the end user.

THE COMPUTER SYSTEM

. The computer system consists of four types namely;

a. *Hardware* consists of the mechanical parts that make up the computer as a machine. The hardware consists of physical devices of the computer. The devices are required for input, output, storage and processing of the data. Keyboard, monitor, hard disk drive, floppy disk drive, printer, processor and motherboard are some of the hardware devices.

b. *Software* is a set of instructions that tells the computer about the tasks to be performed and how these tasks are to be performed. *Program* is a set of instructions, written in a language understood by the computer, to perform a specific task. A set of programs and documents are collectively called software. The hardware of the computer system cannot perform any task on its own. The hardware needs to be instructed about the task to be performed. Software instructs the computer about the task to be performed. The hardware carries out these tasks. Different software can be loaded on the same hardware to perform different kinds of tasks.

c. *Data/information and communication ware* are isolated values or raw facts, which by themselves have no much significance. For example, the data like 29, *January*, and *1994* just represent values. The data is provided as input to the computer, which is processed to generate some meaningful information. For example, 29,
January and 1994 are processed by the computer to give the date of birth of a person.

d. *User/human ware* refers people who write computer programs or interact with the computer. They are also known as *skin ware, live ware, human ware or people ware*. Programmers, data entry operators, system analyst and computer hardware engineers fall into this category.

Parts of computer system

<p align="center">**CHARACTERISTICS OF A COMPUTER**</p>

The following are the characteristics of a computer;

- ✓ **Speed:** The computer can process data very fast, at the rate of millions of instructions per second.
- ✓ **Accuracy:** Computer provides a high degree of accuracy. For example, the computer can accurately give the result of division of any two numbers up to 10 decimal places.
- ✓ **Diligence:** When used for a longer period of time, the computer does not get tired or fatigued. It can perform long and complex calculations with the same speed and accuracy from the start till the end.
- ✓ **Storage Capability:** Large volumes of data and information can be stored in the computer and also retrieved whenever required.
- ✓ **Versatility:** Computer is versatile in nature. It can perform different types of tasks with the same ease.

ADVANTAGES OF COMPUTER

- They are used in homes for playing video games and as tools for listening to music songs.
- They are used in government offices to facilitate communication amongst the government officials.
- They are used for designing structural drawings in the science and engineering field of civil engineering, using AutoCAD, ArchiCAD and many more.
- They are used in supermarkets to determine the price of the products by the customer using barcodes.
- They are used in schools to print the examinations scripts and for marking examinations.

DISADVANTAGES OF COMPUTER

- The uncontrolled addiction to computer may cause eye strain and back pain when used for a long time.
- The computers connected to the internet can lead to degeneration among the youths by visiting unnecessary websites.
- The computers are expensive to buy therefore it is costly for everyone to afford.
- The computers are highly vulnerable to dusty environment and therefore when exposed to dust they get damage internally.
- They require a special technician for their maintenance which is also costly to the user.
- The computers are used by only computer literates and hence not every individual could access them.

APPLICATION OF COMPUTERS

The followings are some of the application areas of the computer are listed below—

➢ *Education*

Computers are extensively used, as a tool and as an aid, for imparting education. Educators use computers to prepare notes and presentations of their lectures. Computers are used to develop computer-based training packages, to provide distance education using the e-learning software, and to conduct online examinations. Researchers use computers to get easy access to conference and journal details and to get global access to the research material.

➢ *Entertainment*

Computers have had a major impact on the entertainment industry. The user can download and view movies, play games, chat, book tickets for cinema halls, use multimedia for making movies, incorporate visual and sound effects using computers, etc. The users can also listen to music, download and share music, create music using computers, etc.

➢ *Sports*

A computer can be used to watch a game, view the scores, improve the game, play games (like chess, etc.) and create games. They are also used for the purposes of training players.

➢ *Advertising*

Computer is a powerful advertising media. Advertisement can be displayed on different websites, electronic-mails can be sent and reviews of a product by different customers can be posted. Computers are also used to create an advertisement using the visual and the sound effects. For the advertisers, computer is a medium via which the advertisements can be viewed globally. Web advertising has become a significant factor in the marketing plans of almost all companies. In fact, the business model of Google is mainly dependent on web advertising for generating revenues.

➢ *Medicine*

Medical researchers and practitioners use computers to access information about the advances in medical research or to take opinion of doctors globally. The medical history of patients is stored in the computers. Computers are also an integral part of various kinds of sophisticated medical equipment like ultrasound machine, CAT scan machine, MRI scan machine, etc. Computers also provide assistance to the medical surgeons during critical surgery operations like laparoscopic operations, etc.

➢ *Science and Engineering*
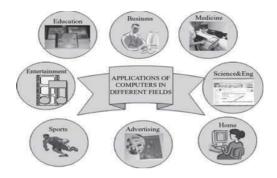
Scientists and engineers use computers for performing complex scientific calculations, for designing and making drawings (CAD/CAM applications) and also for simulating and testing the designs. Computers are used for storing the complex data, performing complex calculations and for visualizing 3−dimensional objects. Complex scientific applications like the launch of the rockets, space exploration, etc., are not possible without the computers.

➢ *Government*

The government uses computers to manage its own operations and also fore-governance. The websites of the different government departments provide information to the users. Computers are used for the filing of income tax return,

paying taxes, online submission of water and electricity bills, for the access of land record details, etc. The police department uses computers to search for criminals using fingerprint matching, etc.

➢ *Home*

Computers have now become an integral part of home equipment. At home, people use computers to play games, to maintain the home accounts, for communicating with friends and relatives via Internet, for paying bills, for education and learning, etc. Microprocessors are embedded in house hold utilities like, washing machines, TVs, food processors, home theatres, security devices, etc.

Application areas of computer

TYPES OF COMPUTERS

There are basically three types of computers namely:

a. DIGITAL COMPUTERS

A *digital computer* uses distinct values to represent the data internally. All information are represented using the digits 0's and 1's. The computers that we use at our homes and offices are digital computers.

b. Analog computer

Analog computer is another kind of a computer that represents data as variable across a continuous range of values. The earliest computers were analog computers. Analog computers are used for measuring of parameters that vary continuously in real time, such as temperature, pressure and voltage. Analog computers may be more flexible but generally less precise than digital computers. Slide rule is an example of an analog computer.

c. HYBRID COMPUTER
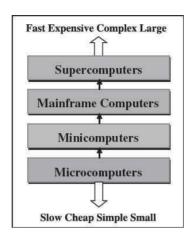
This type of computer combines the characteristics of both the analog and digital computers.

CLASSIFICATION OF COMPUTERS

The digital computers that are available nowadays vary in their sizes and types. The computers are broadly classified into four categories based on their size and type:

✓ Microcomputers

- ✓ Minicomputers
- ✓ Mainframe computers
- ✓ Supercomputer.

Classification of computers based on size and type

A. MICROCOMPUTERS

Microcomputers are small, low-cost and single-user digital computer. They consist of CPU, input unit, output unit, storage unit and the software. Although microcomputers are stand-alone machines, they can be connected together to create a network of computers that can serve more than one user. IBM PC based on Pentium microprocessor and Apple Macintosh are some examples of microcomputers. Microcomputers include desktop computers, notebook computers or laptop, tablet computer, handheld computer, smart phones and netbook.

- ✓ *Desktop Computer or Personal Computer (PC)* is the most common type of microcomputer. It is a stand-alone machine that can be placed on the desk. Externally, it consists of three units keyboard, monitor, and a system unit containing the CPU, memory, hard disk drive, etc. It is not very expensive and is suited to the

needs of a single user at home, small business units, and organizations. Apple, Microsoft, HP, Dell and Lenovo are some of the PC manufacturers.

✓ *Notebook Computers or Laptop* resemble a notebook. They are portable and have all the features of a desktop computer. The advantage of the laptop is that it is small in size (can be put inside a briefcase), can be carried anywhere, has a battery backup and has all the functionality of the desktop. Laptops can be placed on the lap while working (hence the name). Laptops are costlier than the desktop machines.

✓ *Netbook:* These are smaller notebooks optimized for low weight and low cost, and are designed for accessing web-based applications. Starting with the earliest netbook in late 2007, they have gained significant popularity now. Netbooks deliver the performance needed to enjoy popular activities like streaming videos or music, emailing, Web surfing or instant messaging. The word *netbook* was created as a blend of Internet and note*book*.

✓ *Tablet: Computer* has features of the notebook computer but it can accept input from a stylus or a pen instead of the keyboard or mouse. It is a portable computer. Tablet computer are the new kind of PCs.

✓ *Handheld Computer or Personal Digital Assistant (PDA):* is a small computer that can be held on the top of the palm. It is small in size. Instead of the keyboard, PDA uses a pen or a stylus for input. PDAs do not have a disk drive. They have a limited memory and are less powerful. PDAs can be connected to the Internet via a wireless connection. Casio and Apple are some of the manufacturers of PDA. Over the last few years, PDAs have merged into mobile phones to create smart phones.

✓ *Smart Phones* are cellular phones that function both as a phone and as a small PC. They may use a stylus or a pen, or may have a small keyboard. They can be connected to the Internet wirelessly. They are used to access the electronic-mail, download music, play games, etc. Blackberry, Apple, HTC, Nokia and LG are some of the manufacturers of smart phones.

MINICOMPUTERS

Minicomputers are digital computers, generally used in multi-user systems. They have high processing speed and high storage capacity than the microcomputers. Minicomputers can support 4–200 users simultaneously. The users can access the minicomputer through their PCs or terminal. They are used for real-time applications in industries, research centers, etc. PDP 11, IBM (8000 series) are some of the widely used minicomputers.

MAINFRAME COMPUTERS

Mainframe computers are multi-user, multi-programming and high performance computers. They operate at a very high speed, have very large storage capacity and can handle the workload of many users. Mainframe computers are large and powerful systems generally used in centralized databases. The user accesses the mainframe computer via a terminal that may be a dumb terminal, an intelligent terminal or a PC. A *dumb terminal* cannot store data or do processing of its own. It has the input and output device only. An *intelligent terminal* has the input and output device, can do processing, but, cannot store data of its own. The dumb and the intelligent terminal use the processing power and the storage facility of the mainframe computer.

Mainframe computers are used in organizations like banks or companies, where many people require frequent access to the same data. Some examples of mainframes are CDC 6600 and IBM ES000 series.

Mainframe computer

SUPERCOMPUTERS

Supercomputers are the fastest and the most expensive machines. They have high processing speed compared to other computers. The speed of a supercomputer is generally measured in FLOPS (Floating point Operations Per Second). Some of the faster supercomputers can perform trillions of calculations per second. Supercomputers are built by interconnecting thousands of processors that can work in parallel.

Supercomputer

CHAPTER TWO

COMPUTER HARDWARE COMPONENTS

1. **INPUT DEVICES**

Input devices that require data to be entered manually to the computer are identified as human data entry devices. The data may be entered by typing or keying in, or by pointing a device to a particular location.

a. **Keyboard**

Features Keyboard is a common input device. It is provided along with the computer, and is easy to use. It is used for entering the text data. For inputting the data, the user types the data using the keyboard. When the data is being typed, the display monitor displays the typed data.

Cursor is a vertical line, an underscore, blinking line, etc. Cursor moves with each typed character. The position of cursor indicates the location on monitor where the typed-in character will be displayed.

Description The design of a keyboard is similar to a standard typewriter. The modern keyboards are QWERTY keyboard (Q, W, E, R, T, Y are the sequence of keys in top row of letters).

Standard keyboard contains 101 keys which are arranged in the same order as a typewriter. The keyboard has five sections

(1) Typing keys (1, 2, 3..., A, B, C...),

(2) Numeric keypad (numeric

keys on right side),

(3) Function keys (F1, F2.... on top side),

(4) Control keys (cursor keys, ctrl,

alt....), and

(5) Special-purpose keys (Enter, shift, spacebar...). Some keyboards have 110 keys, where the extra keys are designed to work with the Windows operating system.

Working When a key is pressed, keyboard interacts with a keyboard controller and keyboard buffer. The keyboard controller stores the code of pressed key in keyboard buffer and informs the computer software that an action has happened on the

keyboard. The computer software checks and reads the keyboard buffer and passes the code of pressed character to the system software. Due to a time gap between pressing of a key on keyboard and reading by the system software, keyboard buffer is designed to store many keystrokes together.

Keyboard

b. Pointing Devices

Pointing devices are used for providing the input to computer by moving the device to point to a location on computer monitor. The input data is not typed; instead, the data is entered by moving the pointing device. The cursor on the computer monitor moves with the moving pointing device. Operations like move, click and drag can be performed using the pointing devices. Mouse, trackball, joystick and digitizing tablet are some of the common pointing devices.

(i)   Mouse

It is the most common pointing input device. The data is entered by pointing the mouse to a location on the computer screen. The mouse may also be used to position the cursor on screen, move an object by dragging, or select an object by clicking. The key benefit of using a mouse is that the cursor moves with the mouse. So, the cursor can be positioned at any location on the screen by simply moving the mouse. Moreover, it provides an easy way to select and choose commands from menus, dialog boxes, icons, etc. Mouse is used extensively, while working with graphics elements such as line, curve, shapes, etc.

Description Mouse is a small hand-held device having two or three buttons on its upper side. In addition to the buttons, mouse also has a small wheel between the buttons. The wheel of the mouse is used for the up and down movement, for example, scrolling a long document. A mouse is classified as physical mouse or optical mouse.

| (a) Mouse | (b) A user working with a mouse |

Using the mouse:
 The mouse can be used in five different ways, as follows—
   Pointing points to a location or object on the computer screen. Moving the mouse by hand moves the cursor on computer screen. The cursor moves in the direction in which the mouse moves.
   Left Click or Click means pressing the left button of mouse and releasing it. Clicking is used to select a button, command or icon on the screen.
   Right Click involves pressing the right button on mouse and releasing it. Right click displays a menu that contains options like cut, copy, paste, font, paragraph, etc. for the item on which the mouse is pointing.
   Double Click means pressing the left button of mouse twice successively, without moving the mouse, and then releasing the mouse. It is used to start a program or open a folder.
   Drag and Drop drags an object and drops it at another location. Drag means pointing mouse to an object on screen, pressing the left button of mouse, keeping it pressed and moving the mouse to point to a new location. The object gets dragged to the new location along with the mouse. When the left button of mouse is released, the object gets dropped at the new location. Drag and drop is used for moving folders, files and icons to new locations on the screen.

(ii)   TrackBall

 Trackball is a device that is a variant of the mouse but has the functionality of mouse.
It is easy to use and takes less space than a mouse. Trackball is generally built in laptops since there is no space for the mouse to move on the lap. Trackballs come in various sizes—small and big.

Description:
 Trackball looks like an upside-down mouse. Instead of moving the whole device to move the cursor on computer screen, trackball requires the ball to be rotated manually with a finger. The trackball device remains stationary. The cursor on the

computer screen moves in the direction in which the ball is moved. The buttons on trackball are used in the same way as mouse buttons.

Trackball

(iii) Joystick

Joystick is a device which is commonly used for playing video games. Joystick is mainly used to control the speed of the cursor and is thus popular in games involving speed like racing and flying games. The direction of push of the stick and the amount of deflection determines the change in position and the change in speed, respectively.

Description:

It is a stick with its base attached to a flexible rubber sheath inside a plastic cover. The plastic cover contains the circuit that detects the movement of stick and sends the information to computer. The position of the stick movement is given by the x and y coordinates of the stick.

Joystick

(iv) Digitizing Tablet

It is an input device used primarily to input drawings, sketches, etc. Digitizing tablet is used for Computer Aided Design (CAD) for the design of buildings, automotive designs, and designing of maps, etc.

Description:

Digitizing tablet consists of two parts—electronic tablet and pen. The electronic tablet is a flat-bed tablet. The pen looks like a ball pen but has an electronic head. The pen in moved on the tablet. Each position on the tablet corresponds to a fixed position on the screen.
Drawings can be made on the tablet using a pen, and is provided as input to

computer, where, a location on the tablet corresponds to a specific location on the screen.

Working:
 The tablet contains circuit that can detect the movement of pen on the tablet, convert the movements into digital signals and send the digital signal to the computer.

Digitizing tablet

c. Pick Devices

Pick devices are used for providing input to the computer by pointing to a location on the computer monitor. The input data is not typed; the data is entered by pointing the pick device directly on the computer screen. Light pen and touch screen are some common pick devices.

(i) Light Pen

 It is a light sensitive pen-like input device and is used to select objects directly on the computer screen. It is used for making drawing, graphics and for menu selection. Figures and drawings can be made by moving the pen on computer screen.

Description and Working:
 The pen contains a photocell in a small tube. When the pen is moved on the screen, light from the screen at the location of pen causes the photocell to respond. The electric response is transmitted to the computer that can identify the position on screen at which the light pen is pointing.

Using a light pen

(ii) Touch Screen

It is an input device that accepts input when the user places a fingertip on the computer screen. The computer selects the option from the menu of screen to which the finger points.

Touch screen are generally used in applications like Automated Teller Machine (ATM), public information computers like hospitals, airline reservation, railway reservation, supermarkets, etc.
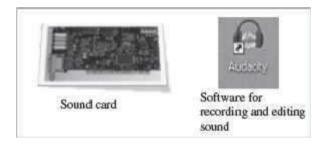

Touch screen of an ATM

Description:

Touch screen consists of a clear glass panel that is placed over the view area of computer screen. In addition to the glass panel with sensors, it has a device driver, and a controller that translates the information captured by the glass panel sensors to a form that the computer can understand.

Working:

Touch screens have an infrared beam that criss-cross the surface of screen. When a fingertip is touched on the screen, the beam is broken, and the location is recorded. Some touch screens have ultrasonic acoustic waves that cross the surface of screen. When a fingertip is touched on the screen, the wave is interrupted, and the location is recorded. The recorded location is sent to the computer via the controller of touch screen, in a form that the computer can understand.

d. Audio Input Device

Audio input can be provided to the computer using human voice or speech. Audio input to the computer can be used for different purposes. It can be used for making telephone calls, for audio and video conferencing over Internet, to record voice, to create audio files and embed these files to be sent over e-mail, or, to translate spoken words into text, etc. Audio input device like a *microphone* is used to input a person's voice into the computer. *A sound card* translates analog audio signals from microphone into digital codes that the computer can store and process. Sound card also translates back the digital sound into analog signals that can be sent to the speakers. Translating spoken words into text is also known as *speech recognition or voice recognition*. The audio input along with the software for voice recognition forms the speech recognition system or voice recognition system.

(i) Sound card   (ii) Audacity software

The computer can be operated using voice commands. The user can dictate the commands to the computer, instead of typing them. The computer has to be trained to recognize the voice of user using the speech patterns and pronunciation of words. The system thus adapts to the voice of user. Speech recognition systems are costly and difficult to develop. They are generally used by people who have difficulty in typing, people with disabilities or by corporate world for dictation.
Audio input can be recorded on an mp3 recorder and provided as an input to computer. Open source software like Audacity is used for recording and editing of audio files.

e. Video Input Device

Video input is provided to the computer using *video camera and digital camera.*
  (i)   Video camera can capture full motion video images. The images are digitized and can be compressed and stored in the computer disk. Webcam is a common video camera device. It is placed on the computer above the screen to capture the images of the user who is working on the computer. A video capture card allows the user to connect video devices like camcorders to the computer.

  (ii)   Digital camera works like video camera but can capture still images. The digital camera digitizes images, compresses them and stores them on a memory card like flash memory. The information from the digital camera can be brought into the computer and stored. The video files can be edited

using software like VLC media player. Computer vision is an area of computer science that deals with images. Computer vision has applications in areas like robotics and industrial processing.

Video input devices

f.   Optical Input Devices

Optical input devices allow computers to use light as a source of input. Scanner is an example of optical input device. Other common optical input devices are magnetic ink character reader used for Magnetic Ink Character Recognition (MICR), optical mark reader used for Optical Mark
Recognition (OMR), optical character reader for Optical Character Recognition (OCR) and
Barcode Reader.

(i)   Scanner

Scanner is an input device that accepts paper document as an input. Scanner is used to input data directly into the computer from the source document without copying and typing the data. The input data to be scanned can be a picture, a text or a mark on a paper. It is an optical input device and uses light as an input source to convert an image into an electronic form that can be stored on the computer. Scanner accepts the source paper document, scans the document and translates it into a bitmap image to be stored on the computer. The denser the bitmap, the higher is the resolution of the image. The quality of scan increases with the increase in resolution. Scanners come with utility software that allows the stored scanned documents to be edited, manipulated and printed. Hand-held scanner and flat-bed scanner are the two common types of scanners.

Hand-held Scanners are portable and are placed over the document to be scanned. They consist of light emitting diodes. The scanned documents are converted and stored as an image in the computer memory. Hand-held scanners have to be moved at a constant speed over the document to be scanned, to get good quality scans. They are preferably used for low volume of documents, small pictures or photos. They are difficult to use if there is a need to scan a full page document. Some of the documents that are primarily scanned using hand-held scanners are price tags, label and ISBN number on books.

Flat-bed Scanners provide high quality scan in a single pass. It is a box shaped machine similar to a photocopy machine and has a glass top and a lid that covers the glass.
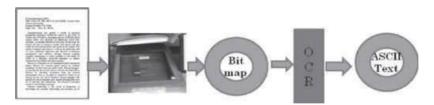
The document to be scanned is placed on the glass top, which activates the light beam beneath the glass top and starts the scan from left to right. They are largely used to scan full page documents.

Flat-bed scanner

(ii)   Optical Character Recognition (OCR)

OCR is a technique for the scanning of a printed page, translating it, and then using the OCR software to recognize the image as ASCII text that is editable. OCR uses optical character reader for recognition. The optical character reader stores the scanned image as bitmap image which is a grid of dots. Thus, you cannot edit the text that has been scanned. To edit the scanned text, you need OCR software. The OCR software translates the array of dots into text that the computer can interpret as words and letters. To recognize the words and letters of text, the OCR software compares the pattern on the scanned image with the patterns stored inside the computer. The text files generated via OCR can be stored in different formats.
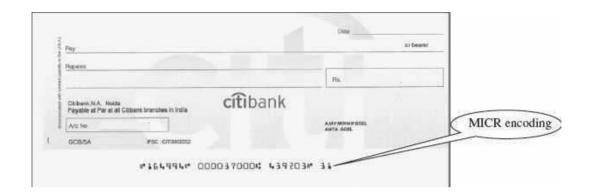

OCR system

(iii)   Magnetic Ink Character Recognition (MICR)

MICR is used in banks to process large volumes of cheques. It is used for recognizing the magnetic encoding numbers printed at the bottom of a cheque. The numbers on the cheque are human readable, and are printed using an ink which contains iron particles. These numbers are magnetized. MICR uses magnetic ink character reader for character recognition.

When a cheque is passed through Magnetic Ink Character Reader, the magnetic field causes the read head to recognize the characters or numbers of cheque. The readers are generally used in banks to process the cheques. The numbers in the bottom of the cheque include the bank number, branch number and cheque number. The reading speed of MICR is faster than OCR.

MICR encoded cheque

(iv)   Optical Mark Recognition (OMR)

OMR is used to detect marks on a paper. The marks are recognized by their darkness. OMR uses an optical mark reader to read the marks. The OMR reader scans the forms, detects the mark that

is positioned correctly on the paper and is darker than the surrounding paper, and passes this information to the computer for processing by application software. For this, it uses a beam of light that is reflected on the paper with marks, to capture presence and absence of marks. The optical mark reader detects the presence of mark by measuring the reflected light. The pattern of marks is interpreted and stored in the computer.

OMR is widely used to read answers of objective type tests, where the student marks an answer by darkening a particular circle using a pencil. OMR is also used to read forms, questionnaires, order forms, etc.

OMR mark sheet

(v)   Barcode Reader

Barcodes are adjacent vertical lines of different width that are machine readable. Products at supermarkets and books use barcode for identification. Barcodes are read using reflective light by barcode readers. This information is input to the computer which interprets the code using the spacing and thickness of bars. Hand-held barcode readers are generally used in departmental stores to read the labels, and in libraries to read labels on books.

A barcode printed at the back of a book.

Barcode readers are fast and accurate. They enable faster service to the customer and are also used to determine the items being sold, number of each item sold or to retrieve the price of item.

2. OUTPUT DEVICES

Output devices provide output to the user, which is generated after processing the input data. The processed data, presented to the user via the output devices could be text, graphics, audio or video. The output could be on a paper or on a film in a tangible form, or, in an intangible form as audio, video and electronic form. Output devices are classified as follows—

a. **Hard Copy Devices**
- Printer
- Plotter
- Computer Output on Microfilm (microfiche)

b. **Soft Copy Devices**
- Monitor
- Visual Display Terminal
- Video Output

A. Hard Copy Devices

The output obtained in a tangible form on a paper or any surface is called hard copy output. The hard copy can be stored permanently and is portable. The hard copy output can be read or used without a computer. The devices that generate hard copy output are called hard copy devices.

Printer, plotter and microfiche are common hard copy output devices.

(i) Printer

A printer prints the output information from the computer onto a paper. Printers are generally used to print textual information, but nowadays printers also print graphical information. The print quality (sharpness and clarity of print) of the printer is determined by the resolution of the printer. Resolution is measured in dots per inch (dpi). Printers with a high resolution (more dpi) provide better quality output. Different kinds of printers are available for different types of applications. Printers are classified into two categories—impact printer and non-impact printer.

- **Impact printers** use the typewriter approach of physically striking a typeface against the paper and inked ribbon. Impact printers can print a character or an entire line at a time. Impact printers are low-cost printers useful for bulk

printing. Dot matrix printers, daisy wheel printers and drum printers are examples of impact printers.

- ❖ *Dot Matrix Printers* print one i character at a time. The speed of dot matrix printer lies between 200 and 600 characters per second (cps) and their resolution ranges from 72 to 360 dpi. Dot matrix printers normally come in two sizes—80 column printer and 132 column printer. Dot matrix printers can print alphanumeric characters, special characters, charts and graphs. They can print only in black and white. Some dot matrix printers can print in both directions - left to right and right to left. Dot matrix printers are commonly used for printing in applications like payroll and accounting.

Dot matrix printer

- ❖ *Daisy Wheel Printers* print one character at a time. They produce letter quality document which is better than a document printed by a dot matrix printer. The speed of daisy wheel printers is about 100 cps. The print head of the printer is like a daisy flower, hence the name. These printers are slow, can only print text (not graphics), and are costly in comparison to dot matrix printers. Daisy wheel printers are used where high quality printing is needed and no graphics is needed.

Daisy wheel for printers

- ❖ *Drum Printers are line printers*. They are expensive and faster than character printers but produce a low quality output. They can print 200–2500 lines per minute. Drum printers are generally used for voluminous print outputs.

- **Non-Impact** Printers do not hit or impact a ribbon to print. They use electro-

static chemicals and ink-jet technologies. Non-impact printers are faster and quieter than impact printers. They produce high quality output and can be used for printing text and graphics both in black and white, and color. Ink-jet printers and laser printers are non-impact printers.

❖ *Ink-jet Printers* spray ink drops directly on the paper like a jet. Their resolution is more than 500 dpi. They produce high quality graphics and text. Ink-jet printers are commonly found in homes and offices.

❖ *Laser Printers* provide highest quality of text and graphics printing. Laser printers process and store the entire page before printing and are also known as *page printers*. The laser printer can print 5–24 pages of text per minute and their resolution ranges from 400 to 1200 dpi. They are faster and expensive than impact printers. Laser printers are used in applications requiring high quality voluminous printing.

(i) Inkjet printer   (ii) Laser printer

(ii)   **Plotter**

A plotter is used for vector graphics output to draw graphs, maps, blueprints of ships, buildings, etc. Plotters use pens of different colors (cyan, magenta, yellow and black) for drawing. Plotters draw continuous and accurate lines, in contrast to printers where a line is drawn as closely spaced dots. Plotter is a slow output device and is expensive. Plotters are of two kinds—drum plotter and flatbed plotter. In a *drum plotter*, pens mounted on the carriage are stationary and move only horizontally; for vertical movement, the drum on which the paper is fixed moves clockwise and anti-clockwise. In a *flatbed plotter*, the paper is fixed on a flat bed.
The paper is stationary and the pens mounted on the carriage move horizontally and vertically to draw lines. Plotters are mainly used for drawings in AUTOCAD (computer assisted drafting), Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) applications.

Plotter

(iii)   Computer Output on Microfilm

A microfilm is in a fiche or roll format, and is used to record computer output directly from the computer tape or cartridge. Computer Output on Microfilm (COM) is a high speed and low cost process. It can produce data in microfilm form at a much faster speed from that of a paper printer. The standard roll film is 16 mm wide with a film image that is 1/24 of the original document. The copy of the image on microfilm retains its original clarity. Microfilm can be indexed to facilitate retrieving information from it. For reading images stored on microfilm, a microfilm reader is used. A screen is used for viewing the enlarged images. COM is suited for storing large amounts of data for manuals and archive records for long periods of time that have to be referenced occasionally. COM is used for storing output in banking and insurance applications, medical X-rays, etc.

Microfilm

B. Soft Copy Devices

The output obtained in an intangible form on a visual display, audio unit or video unit is called soft copy output. The soft copy allows corrections to be made, can be stored, and, can be sent via
E− to other users. The soft copy output requires a computer to be read or used. The devices that generate soft copy output are called soft copy devices. Visual output devices like computer monitor, visual display terminal, video system and audio response system are common soft copy output devices.

(i)   Monitor

Monitor is a common output device. The monitor is provided along with the computer, to view the displayed output. A monitor is of two kinds - monochrome displays monitor and color display monitor. A monochrome display monitor uses only one color to display text and color display monitor can display 256 colors at one time. The number of colors displayed by a color monitor varies with the kind of color adapter attached to it—CGA, EGA, VGA, XGA and SVGA. The CGA monitor supports four colors and SVGA supports around 16,000,000 colors. Monitors are available in

various sizes like 14, 15, 17, 19 and 21 inches.

An image on the monitor is created by a configuration of dots, also known as pixels. The clarity of image on the computer screen depends on three factors—

1. *Resolution of Screen*—the number of pixels in horizontal and vertical direction. More the number of pixels, the sharper is the image. The common resolution of computer screen is 800x600 and 1024x768,

2. *Dot Pitch*—the diagonal distance between two colored pixels on a display screen, and

3. *Refresh Rate*—the number of times per second the pixels are recharged so that their glow remains bright.

Monitors may be *Cathode Ray Tube* (CRT) monitors that look like a television or *Liquid Crystal Display* (LCD) monitors that have a high resolution, flat screen, and flat panel display. Nowadays, LCD monitors are generally used.

(ii)   Visual Display Terminal

A monitor and keyboard together are known as *Visual Display Terminal* (VDT). A keyboard is used to input data and monitor is used to display the output from the computer. The monitor is connected to the computer by a cable. Terminals are categorized as dumb, smart and intelligent terminals. The dumb terminals do not have processing and programming capabilities. Smart terminals have built-in processing capability but do not have its own storage capacity. Intelligent terminals have both built-in processing and storage capacity.

CRT monitor

(iii)   Video Output

Screen image projector or data projector is an output device that displays information from the computer onto a large white screen. The projector is mainly used to display visual output to a large gathering of people required for the purposes of teaching, training, meetings, conference presentations, etc.

A user viewing the output on a LCD monitor   (i) LCD projector   (ii) A presentation in progress using LCD projector

3. STORAGE DEVICES [SECONDARY MEMORY]

The RAM (Random Access Memory) is expensive and has a limited storage capacity. Since it is a volatile memory, it cannot retain information after the computer is powered off. Thus, in addition to primary memory (RAM), an auxiliary or secondary memory is required by a computer. The secondary memory is also called the storage device of computer.The data and instructions stored in secondary memory must be fetched into RAM before processing is done by CPU.

The information stored in storage devices can be accessed in two ways—
1. Sequential access
2. Direct access

❖ Sequential Access Devices
Sequential access means that computer must run through the data in sequence, starting from the beginning, in order to locate a particular piece of data. Magnetic tape is an example of sequential access device. Sequential access devices are generally slow devices.

❖ Direct Access Device
Direct access devices are the ones in which any piece of data can be retrieved in a non-sequential manner by locating it using the data's address. It accesses the data directly, from a desired location. Magnetic disks and optical disks are examples of direct access devices.. Based on access, magnetic tapes are sequential access devices, and, magnetic disks, optical disk and magneto-optical disks are direct access devices.

TYPES OF STORAGE DEVICES

a. MAGNETIC TAPE

Magnetic tape is a plastic tape with magnetic coating. It is storage medium on a large open reel or in a smaller cartridge or cassette (like a music cassette). Magnetic tapes are cheaper storage media. They are durable, can be written, erased, and re-written. Magnetic tapes are sequential access devices, which mean that the tape needs to rewind or move forward to the location where the requested data is positioned in the magnetic tape. Due to their sequential nature, magnetic tapes are not suitable for data files that need to be revised or updated often.
They are generally used to store back-up data that is not frequently used or to transfer data from one system to other.
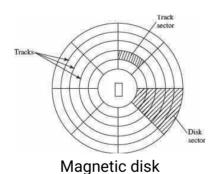
A 10.5-inch reel of 9-track tape

Characteristics of magnetic tape

Inexpensive storage device
Can store a large amount of data
Easy to carry or transport
Not suitable for random access data
Slow access device
Needs dust prevention, as dust can harm the tape
Suitable for back-up storage or archiving

3.10 MAGNETIC DISK

Magnetic disk is a direct access secondary storage device. It is a thin plastic or metallic circular plate coated with magnetic oxide and encased in a protective cover. Data is stored on magnetic disks as magnetized spots. The presence of a magnetic spot represents the bit 1 and its absence represents the bit 0.

Magnetic disk

Characteristics of magnetic disk

Cheap storage device
Can store a large amount of data
Easy to carry or transport
Suitable for frequently read/write data
Fast access device
More reliable storage device
To be prevented from dust, as the read/write head flies over the disk. Any dust particle in between can corrupt the disk.

Note: Floppy disk, hard disk and zip disk are the different types of magnetic disks.

OPTICAL DISK

Optical disk is a flat and circular disk which is coated with reflective plastic material that can be altered by laser light. Optical disk does not use magnetism. The bits 1 and 0 are stored as spots that are relatively bright and light, respectively.

An optical disk consists of a single spiral track that starts from the edge to the center of disk. Due to its spiral shape, it can access large amount of data sequentially, for example music and video. The random access on optical disk is slower than that of magnetic disk, due to its spiral shape.

Optical disk

Types of Optical disk

a. CD-ROM

Originally, Compact Disk (CD) was a popular medium for storing music. Now, it is used in computers to store data and is called Compact Disk-Read Only Memory (CD-ROM).

CD-ROM is an optical disk that can only be read and not written on. CD-ROM is written on by the manufacturer of the CD-ROM using the laser light.

A CD-ROM drive reads data from the compact disk. Data is stored as pits (depressions) and lands (flat area) on CD-ROM disk. When the laser light is focused on the disk, the pits scatter the light (interpreted as 0) and the lands reflect the light to a sensor (interpreted as 1).

As CD-ROM is read only, no changes can be made into the data contained in it.

Since there is no head touching the disk, but a laser light, CD-ROM does not get worn out easily.

The storage density of CD-ROM is very high and cost is low as compared to floppy disk and hard disk.

Access time of CD-ROM is less. CD-ROM drives can read data at 150Kbps. They come in multiples of this speed like—2x, 4x, 52x, etc.

It is a commonly used medium for distributing software and large data.

CD-ROM

b. DVD-ROM

Digital Video Disk-Read Only Memory (DVD-ROM) is an optical storage device used

to store digital video or computer data.

   DVDs look like CDs, in shape and physical size.

   It improves on CD technology.

   It is a high-density medium with increased track and bit density.

   DVD-ROM uses both sides of the disk and special data compression technologies. The tracks for storing data are extremely small.

   A full-length movie can be stored on a single disk.

   Each side of DVD-ROM can store 4.7 GB of data, so a single DVD can store 9.4 GB of data.

   New DVD-ROMs use layers of data track, to double its capacity. Such dual layer diskscan store 17 GB of data.

DVD-ROM

c. Recordable Optical Disk

In addition to the read only CDs and DVDs, recordable optical disks are also available. Users can record music, video, audio and data on it.
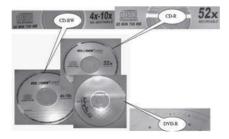
The recordable optical disks are—

   Compact Disk-Recordable (CD-R) is a Write Once-Read Many (WORM) disk. A CD-R disk allows the user to write data permanently on to the disk. Once the data is written, it cannot be erased. CD-R disk uses a laser that burns pits into the disk surface. It looks like a CD disk externally. To write to a CD-R disk, a device named CD-Writer or CD−burner is required. A CD-R disk can store 700 MB of data that can run for 80 minutes. CD-R is used to create music CDs in home computers, back up data from other storage devices, archives of large data, etc.

   Compact Disk-Rewritable (CD-RW) allows data to be written, erased and re-written on.

The capacity of CD-RW is same as a CD. They generally do not play on all CD-ROM drives.

   Digital Video Disk-Recordable (DVD-R) allows recording of data on a DVD. A DVD writer device is required to write the data to DVD. The data once written on a DVD cannot be erased or changed.

d. MAGNETO-OPTICAL DISK

Magneto-optical disks use laser beam to read data and magnetic field to write data to disk.
· These are optical disks where data can be written, erased and re-written.
They are expensive and outdated. They were used during the mid-1990s. They have now been replaced by CD-RW and DVD-R.

CHAPTER THREE

COMPUTER SOFTWARE COMPONENTS

TYPES OF SOFTWARE

Software can be broadly classified in two categories:
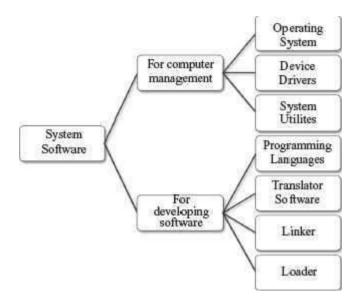- System Software
- Application Software.

❖ **SYSTEM SOFTWARE**

System software is software that provides basic functionality to the computer. System software is required for the working of computer itself.
 The user of computer does not need to be aware about the functioning of system software, while using the computer.

The purposes of the system software are:
- ✓ To provide basic functionality to computer,
- ✓ To control computer hardware, and
- ✓ To act as an interface between user, application software and computer hardware.

On the basis of their functionality, system software may be broadly divided into two categories as follows—

System software

System software for the management and functionality of computer relates to the functioning of different components of the computer, like, processor, input and output devices etc. System software is required for managing the operations performed by the components of computer and the devices attached to the computer. It provides support for various services, as requested by the application software. Operating system, device drivers, and system utilities constitute the system software for management of computer and its resources.

System software for the *development of application software* provides services required for the development and execution of application software. System software provides the software tools required for the development of application software. The programming language software, translator software, loader, and linker are also categorized as system software, and are required for the application software development.

a. Operating System

Operating System (OS) is an important part of a computer. OS intermediates between the user of a computer and the computer hardware. Different kinds of application software use specific hardware resources of a computer like CPU, I/O devices and memory, as needed by the application software. OS controls and coordinates the use of hardware among the different application software and the users. It provides an interface that is convenient for the user to use, and facilitates efficient operations of the computer system resources.

The functions of OS are—
- ✓ It provides an environment in which users and application software can do work.
- ✓ It manages different resources of the computer like the CPU time, memory space, file storage, I/O devices etc. During the use of computer by other programs or users, operating system manages various resources and allocates them whenever required, efficiently.
- ✓ It controls the execution of different programs to prevent occurrence of error.
- ✓ It provides a convenient interface to the user in the form of commands and

graphical interface, which facilitates the use of computer.

Examples of operating systems
- Microsoft Disk Operating System (MS-DOS)
- Windows 7
- Windows XP
- Linux
- UNIX
- Mac OS X Snow Leopard.

b. Device Driver
A device driver acts as a translator between the hardware and the software that uses the devices.
In other words, it intermediates between the device and the software, in order to use the device.
Some devices that are commonly connected to the computer are—keyboard, mouse, hard disk, printer, speakers, microphone, joystick, webcam, scanner, digital camera, and monitor. For proper working of a device, its corresponding device driver must be installed on the computer.
Programmers can write the higher-level application code independently of whatever specific hardware devices it will ultimately use, because code and device can interface in a standard way, regardless of the software superstructure, or of the underlying hardware. Each version of a device, such as a printer, requires its own hardware-specific specialized commands. In contrast, most applications instruct devices (such as a file to a printer) by means of high level generic commands for the device, such as PRINTLN (print a line). The device-driver accepts these generic high-level commands and breaks them into a series of low-level, device-specific commands, as required by the device being driven.
Nowadays, the operating system comes preloaded with some commonly used device drivers, like the device driver for mouse, webcam, and keyboard.

Device drivers: (i) CD of a printer   (ii) Sony audio recorder

c. System Utilities
System utility software is required for the maintenance of computer. System utilities are used for supporting and enhancing the programs and the data in computer. Some system utilities may come embedded with OS and others may be added later on.
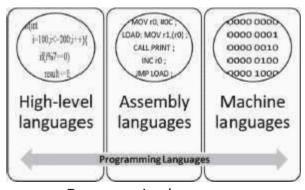
Examples of system utilities

✓ *Anti-virus* utility to scan computer for viruses
✓ *Data Compression* utility to compress the files

✓ *Cryptographic* utility to encrypt and decrypt files.
✓ *Disk Compression* utility to compress contents of a disk for increasing the capacity of a disk.
✓ *Disk Partitioning* to divide a single drive into multiple logical drives. Each drive is then treated as an individual drive and has its own file system.
✓ *Disk Cleaners* to find files that have not been used for a long time. It helps the user to decide what to delete when the hard disk is full.
✓ *Backup Utility* to make a copy of all information stored on the disk. It also restores the backed up contents in case of disk failure.
✓ *System Profiling Utility* provides detailed information about the software installed on the computer and the hardware attached to it.
✓ *Network Managers* to check the computer network and to log events

d. Programming Languages

A Programming Language consists of a set of vocabulary and grammatical rules, to express the computations and tasks that the computer has to perform. Programming languages are used to write a program, which controls the behavior of computer, codify the algorithms precisely, or enables the human-computer interface. Each language has a unique set of keywords (words that it understands) and a special syntax for organizing program instructions. The programming language should be understood, both by the programmer (who is writing the program) and the computer. A computer understands the language of 0·s and 1·s, while the programmer is more comfortable with English-like language. Programming Language usually refers to high-level languages like COBOL, BASIC, FORTRAN, C, C++, Java etc.

Programming languages are categorized into three:

Programming languages

Machine Language is what the computer can understand but it is difficult for the programmer to understand. Machine languages consist of numbers only. Each kind of
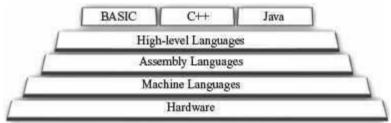CPU has its own unique machine language.
Assembly Language falls in between machine language and high-level language.

They are similar to machine language, but easier to program in, because they allow the programmer to substitute names for numbers.

High-level Language is easier to understand and use for the programmer but difficult for the computer.

Regardless of the programming language used, the program needs to be converted into machine language so that the computer can understand it. In order to do this a program is either compiled or interpreted.

. The choice of programming language for writing a program depends on the functionality required from the program and the kind of program to be written. Machine languages and assembly languages are also called *low-level languages*, and are generally used to write the system software. Application software is usually written in *high-level* languages. The program written in a programming language is also called the *source code*.

A program in machine language

❖ Machine Language

A program written in machine language is a collection of binary digits or bits that the computer reads and interprets. It is a system of instructions and data executed directly by a computer's CPU. It is also referred to as machine code or object code. It is written as strings of 0's and 1·s.

Features of a program written in machine language are:

Machine language code

The computer can understand the programs written in machine language directly. No translation of the program is needed.

Program written in machine language can be executed very fast (Since no translation is required).

Machine language is defined by the hardware of a computer. It depends on the type of the processor or processor family that the computer uses, and is thus machine-dependent. A machine- level program written on one computer may not work on another computer with a different processor.

Computers may also differ in other details, such as memory arrangement, operating systems, and peripheral devices; because a program normally relies on such factors, different computer may not run the same machine language program, even when the same type of processor is used.

Most machine-level instructions have one or more opcode fields which specify the basic instruction type (such as arithmetic, logical, jump), the actual operation (such as add or compare), and some other fields.

It is difficult to write a program in machine language as it has to be written in binary code. For example, 00010001 11001001
Such programs are also difficult to modify.

Since writing programs in machine language is very difficult, programs are hardly written in machine language.

❖ Assembly Language

A program written in assembly language uses symbolic representation of machine codes needed to program a particular processor (CPU) or processor family. This representation is usually defined by the CPU manufacturer, and is based on abbreviations (called mnemonics) that help the programmer remember individual instructions, registers, etc. Small, English-like representation is used to write the program in assembly language.
 Some of the features of a program written in assembly language are as follows:

```
MOV    B, A
MVI    C, 06H
LXI    H, XX50H
ADD    M
JNC    NXTITM
INR    B
INX    H
DCR    C
JNZ    NXTBIT
```

Assembly language code

Assembly language programs are easier to write than the machine language programs, since assembly language programs use short, English-like representation of machine code.
Examples
ADD 2, 3
LOAD A
SUB A, B

The program written in assembly language is the source code, which has to be converted into machine code, also called object code, using translator software, namely, assembler.

Each line of the assembly language program is converted into one or more lines of machine code. Hence assembly language programs are also machine-dependent.

Although assembly language programs use symbolic representation; they are still difficult to write.

Assembly language programs are generally written where the efficiency and the speed of program are the critical issues, i.e. programs requiring high speed and efficiency.

❖ **High-level Language**

A program in a high-level language is written in English-like language. Such languages hide the details of CPU operations and are easily portable across computers. A high-level language isolates the execution semantics of computer architecture from the specification of the program, making the process of developing a program simpler and more understandable with respect to assembly and machine level languages.

The features of a program written in high-level language:

Programs are easier to write, read or understand in high-level languages than in machine language or assembly language. For example, a program written in C++ is easier to understand than a machine language program.

Programs written in high-level languages is the source code which is converted into the object code (machine code) using translator software like interpreter or compiler.

A line of code in high-level program may correspond to more than one line of machine code.

Programs written in high-level languages are easily portable from one computer to another.

❖ **APPLICATION SOFTWARE**

The software that a user uses for accomplishing a specific task is the *application software*.

Application software may be a single program or a set of programs. A set of programs that are written for a specific purpose and provide the required functionality is called software package.

Application software is written for different kinds of applications—graphics, word processors, media players, database applications, telecommunication, accounting purposes etc.

Examples of application software packages are as follows:

Word Processing Software: For writing letter, reports, documents etc. (e.g. MS-WORD).

Image Processing Software: For assisting in drawing and manipulating graphics (e.g. Adobe Photoshop).

Accounting Software: For assisting in accounting information, salary, tax returns (Tally software).

Spreadsheet Software: Used for creating budget, tables etc. (e.g. MS-Excel).

Presentation Software: To make presentations, slide shows (e.g. MS-PowerPoint)

Suite of Software having Word Processor, Spreadsheet and Presentation Software: Some examples are MS-Office, Google Docs, Sun Open office, Apple iWork.

CAD/CAM *Software:* To assist in architectural design. (e.g. AutoCAD, Autodesk)

Geographic Information Systems: It captures, stores, analyzes, manages, and presents data, images and maps that are linked to different locations. (e.g. ArcGIS)

Web Browser Software: To access the World Wide Web to search documents, sounds, images etc. (e.g. Internet Explorer, Netscape Communicator, Chrome).

Some of the application software

SOFTWARE ACQUISITION

Different kinds of software are made available for use to users in different ways. The user may have to purchase the software, can download for free from the Internet, or can get it bundled along with the hardware. Nowadays with the advent of Cloud computing, many applications software are also available on the cloud for use through the Internet, e.g. Google Docs.

The different ways in which the software is made available to users are:

Retail Software is off-the-shelf software sold in retail stores. It comes with printed manuals and installation instructions. For example Microsoft Windows operating system

OEM Software stands for "Original Equipment Manufacturer" software. It refers to software which is sold, and bundled with hardware. Microsoft sells its operating system as OEM software to hardware dealers. OEM software is sold at reduced price, without the manuals, packaging and installation instructions. For example, Dell computers are sold with the "Windows 7" OS pre-loaded on them.

Demo Software is designed to demonstrate what a purchased version of the software is capable of doing and provides a restricted set of features. To use the software, the user must buy a fully- functional version.

Shareware is a program that the user is allowed to try for free, for a specified period of time, as defined in the license. It is downloadable from the Internet. When the trial period ends, the software must be purchased or uninstalled.

Freeware is software that is free for personal use. It is downloadable from the Internet.

The commercial use of this software may require a paid license. The author of the freeware software is the owner of the software, though others may use it for free. The users abide by the license terms, where the user cannot make changes to it, or sell it to someone else.

Public Domain Software is free software. Unlike freeware, public domain software does not have a copyright owner or license restrictions. The source code is publicly available for anyone to use. Public domain software can be modified by the user.

Open-Source Software is software whose source code is available and can be customized and altered within the specified guidelines laid down by the creator. Unlike public domain software, open-source software has restrictions on their use and modification, redistribution limitations, and copyrights. Linux, Apache, Firefox, Open Office are some examples of open-source software.

CHAPTER FOUR

COMPUTER NETWORK

DATA TRANSMISSION MEDIA

The data is sent from one computer to another over a transmission medium. The transmission media can be grouped into guided media, and unguided media.
In the *guided media*, the data signals are sent along a specific path, through a wire or a cable.
Copper wire and optical fibers are the most commonly used guided media. Copper wire transmits data as electric signals. Copper wires offer low resistance to current signal, facilitating signals to travel longer distances. To minimize the effect of external disturbance on the copper wire, two types of wiring is used—

(1) Twisted Pair
(2) Coaxial Pair. Optical fibers transmit data as light signals.

a. Twisted Pair
A twisted pair cable consists of four pairs of copper wires coated with an insulating material like plastic or Teflon, twisted together. The twisting of wires reduces electromagnetic interference from external sources.
Twisted pair cabling is often used in data networks for short and medium length connections because of its relatively lower costs compared to optical fiber and coaxial cable.
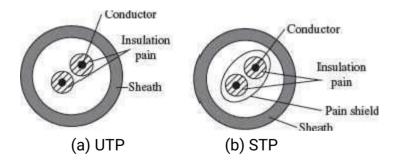Twisted pair is of two kinds—Shielded Twisted Pair (STP), and Unshielded Twisted Pair (UTP).
STP cable has an extra layer of metal foil between the twisted pair of copper wires and the outer covering. The metal foil covering provides additional protection from external disturbances.
However, the covering increases the resistance to the signal and thus decreases the length of the cable. STP is costly and is generally used in networks where cables pass closer to devices that cause external disturbances.
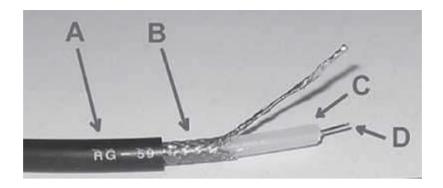*UTP* is the most commonly used medium for transmission over short distances up to 100m. Out of the four pairs of wires in a UTP cable, only two pairs are used for communication.
UTP cables are defined in different categories. The commonly used UTP cable is the Cat-5 *cable* which is used with fast Ethernet.

(a) UTP   (b) STP

b. Coaxial Cable
A coaxial cable has a single inner conductor that transmits electric signals; the outer conductor acts as a ground. The two conductors are separated by insulation. The inner conductor, insulator, and the outer conductor are wrapped in a sheath of Teflon or PVC.

Coaxial cable parts

A: outer plastic sheath
B: woven copper shield
 C: inner dielectric insulator
D: copper core

   The copper wire is used for both inner and outer conductor. The signal is transmitted over the surface of the inner conductor.
   In an ideal coaxial cable the electromagnetic field carrying the signal exists only in the space between the inner and outer conductors. This allows coaxial cable runs to be installed next to metal objects such as gutters without the power losses that occur in other transmission lines, and provides protection of the signal from external electromagnetic interference.
   A thicker coaxial cable can transmit more data than a thinner one.
   The commonly used coaxial cable is *10 base 2* that transmits over a distance of 185 m, and *10 base 5* that transmits over a distance of 500 m.

Optical Fiber
   Optical fibers are being used for transmission of information over large distances more cost effectively than the copper wire connection. Communication systems are now unthinkable without fiber optics.
   Optical fiber transmits data as light signals instead of electric signals.

An optical fiber cable consists of:
(1) core–optical fiber conductor (glass) that transmits light,
 (2) Cladding–an optical material that surrounds the core to prevent any light from escaping the core.
 (3) Jacket–outer covering made of plastic to protect the fiber from damage.

(a) Optical fiber   (b) Cross section of optical fiber

   Modern optical fiber cables can contain up to a thousand fibers in a single cable, so the performance of optical networks easily accommodate large demands for bandwidth on a point to-point basis.

Optical fibers come in two types:

(a) Single-mode fibers

(b) Multi-mode fibers Single-mode fibers have small cores (about $3.5 \times 10 \sim_4$ inches or 9 microns in diameter) and transmit infrared laser light (wavelength = 1,300 to 1,550 nanometers). o Multi-mode fibers have larger cores (about $2.5 \times 10\sim_3$ inches or 62.5 microns in diameter) and transmit infrared light (wavelength ? 850 to 1,300 nm) from Light Emitting Diodes (LEDs).

Advantages of Optical Fibers over wires

- Optical fibers do not cause electrical interference in other cables, since they use light signals.
- Due to much lower attenuation and interference, optical fiber has large advantages over existing copper wire in long-distance and high-demand applications.
- A fiber can carry a pulse of light much farther than a copper wire carrying a signal.
- Optical fiber can carry more information than a wire (light can encode more information than electrical signal).
- A single optical fiber is required for light to travel from one computer to another (two wires are required for electric connection).
- Because signals in optical fibers degrade less, lower-power transmitters can be used instead of the high-voltage electrical transmitters needed for copper wires. Again, this saves your provider and you, money.
- No amplification of the optical signal is needed over distances of hundreds of kilometers. This has greatly reduced the cost of optical networking, particularly over undersea spans where the cost reliability of amplifiers is one of the key factors determining the performance of the whole cable system.
- Optical fibers are ideally suited for carrying digital information, which is especially useful in computer networks.
- They are highly secure as they cannot be tapped and for lack of signal radiation.

Disadvantages of Optical Fiber

- Installing an optical fiber requires special equipment.
- If a fiber breaks, finding the broken location is difficult.
- Repairing a broken optical fiber is difficult and requires special equipment.
- Due to its high installation costs, they are economical when the bandwidth utilization is high.

9.3.4 Radio Transmission

The electromagnetic radio waves that operate at the adio frequency are also used to transmit computer data. rhis transmission is also known as Radio Frequency RF) transmission.

The computers using RF transmission do not require a direct physical connection like wires or cable. Each computer attaches to an antenna hat can both send and receive radio transmission.

Radio transmission

Microwave Transmission

Microwave transmission refers to the technique of transmitting information over a microwave link. Microwaves have a higher frequency than radio waves. Microwave transmission can be aimed at a single direction, instead of broadcasting in all directions (like in radio waves).
Microwaves can carry more information than radio waves but cannot penetrate metals.
Microwaves are used where there is a clear path between the transmitter and the receiver.

Microwave transmission

The advantage of Microwave transmission
    a. It does not require access to all contiguous land along the path of the system, since it does not need cables.

The disadvantages
a. hey need expensive towers and repeaters,
b. They are subject to interference from passing airplanes and rain. Because microwave systems are line-of-sight media, radio towers must be spaced approximately every 42 km along the route.

Satellite Transmission
The communication across longer distances can be provided by combining radio frequency transmission with satellites. Geosynchronous satellites are placed in an orbit synchronized with the rotation of the earth at a distance of 36,000 km above the surface of the earth.
Geosynchronous satellites appear to be stationary when viewed from the earth. The satellite consists of transponder that can receive RF signals and transmit them back to the ground at a different angle. A ground station on one side of the ocean transmits signal to the satellite which in turn sends the signal to the ground station on the other side of the ocean.

Satellite Transmission

DATA TRANSMISSION ACROSS MEDIA
Transmitting data across media implies sending bits through the transmission medium.
Physically, the data is sent as electric signals, radio waves or as light signals. Let's now discuss the use of electric current to transfer digital information. For this, the bits are encoded and sent as characters.

Transmission Modes
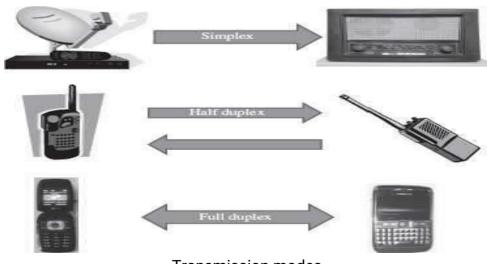The direction in which data can be transmitted between any two linked devices is of three
Types;
(1) Simplex
(2) Half-duplex
(3) Full-duplex or duplex.

Simplex transmission is unidirectional data transmission. Of the two linked devices, only one of them can send data and the other one can only receive data.
Half−duplex transmission is bi-directional data transmission, but the linked devices cannot send and receive at the same time. When one device is sending data the other can only receive. *Full-duplex transmission* is bi-directional and the linked devices can send and receive data simultaneously. The linked devices can send data and at the same time receive data.

The different kinds of transmission modes used for interaction.

Transmission modes

COMPUTER NETWORK

A *computer network* is an interconnection of two or more computers that are able to exchange information. The computers may be connected via any data communication link, like copper wires, optical fibers, communication satellites, or radio links. The computers connected to the network may be personal computers or large main frames. The computers in a network may be located in a room, building, city, country, or anywhere in the world.

Network Types

Computer network is broadly classified into three types—
(1) Local Area Network (LAN)
(2) Metropolitan Area Network (MAN)
(3) Wide Area Network (WAN).

The different network types are distinguished from each other based on the following **characteristics**:
  Size of the network
  Transmission Technology
  Networking Topology

The *size of the network* refers to the area over which the network is spread.
Transmission technology refers to the transmission media used to connect computers on the network and the transmission protocols used for connecting.
Network topology refers to the arrangement of computers on the network or the shape of the network. The following subsections discuss the three types of networks and their characteristics.

Local Area Network (LAN)

LAN is a computer network widely used for local communication. LAN connects computers in a small area like a room, building, office or a campus spread up to a few kilometers. They are privately owned networks, with a purpose to share resources and to exchange information.

Local Area Network (LAN)

The computers in a LAN are generally connected using cables. LAN is different from other types of network since they share the network. The different computers connected to a LAN take turns to send data packets over the cables connecting
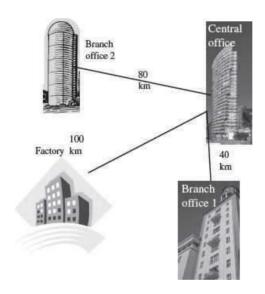
them. This requires coordination of the use of the network. Some of the transmission protocols used in LAN are:

 Ethernet
Token bus
FDDI ring
Star
Bus Ring
 LAN runs at a speed of 10 Mbps to 100 Mbps and has low delays. A LAN based on WiFi wireless network technology is called Wireless Local Area Network (WLAN).

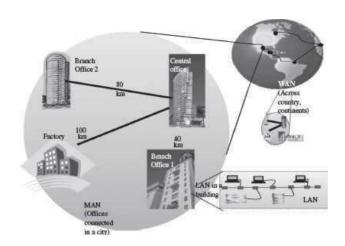### 9.6.1.2 Metropolitan Area Network

MAN is a computer network spread over a city. Cable television network is an example of MAN. The computers in a MAN are connected using coaxial cables or fiber optic cables. MAN also connects several LAN spread over a city.

Metropolitan Area Network (MAN)

Wide Area Network

WAN is a network that connects computers over long distances like cities, countries, continents, or worldwide. WAN uses public, leased, or private communication links to spread over long distances. WAN uses telephone lines, satellite link, and radio link to connect. The need to be able to connect any number of computers at any number of sites, results in WAN technologies to be different from the LAN technologies. WAN network must be able to grow itself. Internet is a common example of WAN.

LAN, MAN and WAN

LAN Topologies

There are different types of network topologies that are used in a network. The network topologies in the structure or the layout of the different devices and computers connected to the network. The topologies commonly used in LAN are—Bus topology, Star topology, and Ring topology.

i. Bus Topology

   All devices on the network are connected through a central cable called a Bus.
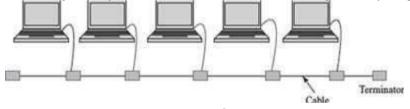   The data signal is available to all computers connected to the bus.
   The data signal carries the address of the destination computer.
   Each computer on the network checks the destination address as the data signal travels through the bus. The computer whose address matches makes a copy of the signal and converts it into data. The data signal on the bus does not get destroyed and still transmits along the bus, and is finally absorbed by the terminator attached to the end of the network.
   It is good for connecting 15–20 computers.
   A single coaxial cable is generally used in bus topology, to which the computers or devices are connected.
   Ethernet is a commonly used protocol in networks connected by bus topology.

Bus topology

ii. Ring Topology

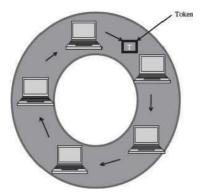   All devices in the network are connected in the form of a ring.
   Each device has a receiver and transmitter to receive the data signals and to send them to the next computer, respectively.
   Ring network does not have terminated ends, thus data signals travel in a circle.
   Ring topology uses token passing method to provide access to the devices in the network.
   The computers or devices are connected to the ring using twisted pair cables, coaxial cables or optic fibers.
   The protocols used to implement ring topology are Token Ring and Fiber Distributed Data Interface (FDDI).

Ring topology

iii. Star Topology

All devices are connected through a central link forming a star-like structure.

The central link is a hub or switch. The computers are connected to the hub or switch using twisted pair cables, coaxial cables or optic fibers.

Star topology is the most popular topology to connect computer and devices in network.

The data signal is transmitted from the source computer to the destination computer via the hub or switch.

The common protocols used in star topology are Ethernet, Token Ring, and Local Talk.

In addition to the bus, ring, and star topologies, there are complex topologies like the tree topology, and the mesh topology used for networking in LAN.

Star topology

Communication Protocol

Data networks are a combination of software and hardware components. The hardware includes transmission media, devices, and transmission equipment. The software allows the hardware to interact with one another and provide access to the network. The application programs that use the network do not interact with the hardware directly. The application programs interact with the protocol software, which follows the rules of the protocol while communicating. *Protocol* is a network term used to indicate the set of rules used by a network for communication.

Advantages and disadvantages of network topologies

|	Bus Topology	Ring Topology	Star Topology
Advantages	Easy to implement (computers connected linearly through cable) Easily extendable (new devices can be easily added) Not very expensive	All computers in the ring have equal access to the ring Each computer in the ring gets an opportunity to transmit data.	Failure of a device attached to the network does not halt the complete network;only that device is down. Easily extendable—by attaching a new device to the hub or switch. No disturbance when a new device is added or removed. Easy to troubleshoot the network.
Disadvantages	If the cable gets damaged, the whole network collapses A computer can transmit data only if network is not being utilized Network slows down if additional computers are connected to the network.	Adding or removing devices is difficult and affects the complete network Failure in a node or the cable breaks down the ring and thus the network. The length of the ring and the number of nodes are limited	It is costly, since each device on the network is attached by a single cable to the central link. Failure of the hub or switch breaks the complete network.
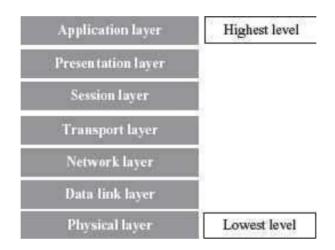
All the computers connected to the network use the protocol software. The network communication protocol is organized as a stack of layers with one layer built upon the other.
Each layer has a specific function and interacts with the layers above and below it. The outgoing data from a computer connected to the network passes down through each layer and the incoming data passes up through each layer. The corresponding layers on the different machines are called *peers*. The peers interact with each other

using the protocol.

The International Standards Organization (ISO) has developed a seven-layer reference model for data networks, known as Open System Interconnection (OSI) model. The OSI model specifies the functions of each layer. It does not specify how the protocol needs to be implemented. It is independent of the underlying architecture of the system and is thus an open system. The seven layers of the OSI model are—
(1) Physical layer
(2) Data link layer
(3) Network layer
(4)Transport layer
(5) Session layer
(6) Presentation layer
(7) Application layer.

OSI model

The functions of the different layers are as follows:

Physical Layer
This layer specifies the basic network hardware. Some of the characteristics defined in the specification are—interface between transmission media and device, encoding of bits, bit rate, error detection parameters, network topology, and the mode of transmission (duplex, half-duplex or simplex).
Data Link Layer
This layer specifies the functions required for node-to-node transmission without errors. It specifies the organization of data into frames, error detection in frames during transmission, and how to transmit frames over a network.
Network Layer
The network layer specifies the assignment of addresses (address structure, length of address etc.) to the packets and forwarding of packets to the destination i.e. routing.
Transport Layer
It specifies the details to handle reliable transfer of data. It handles end-to end error control and flow control, breaking up data into frames and reassembling the frames.
Session Layer
The session layer maintains a session between the communicating devices. It includes specifications for password and authentication, and maintaining synchronization between
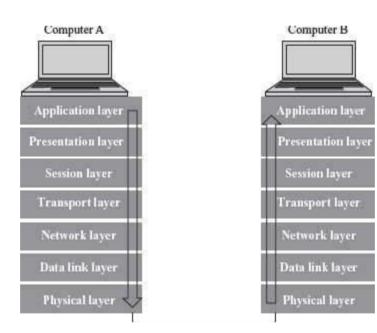
the sender and the receiver.

Presentation Layer

This layer specifies the presentation and representation of data. Its functions include translation of the representation of the data into an identifiable format at the receiver end, encryption, and decryption of data etc.

Application Layer

This layer specifies how an application uses a network. It deals with the services attached to the data. It contains the protocols used by users like HTTP, protocol for file transfer and electronic mail.

Each layer at the sender's side transforms the data according to the function it handles. For this it attaches headers to the data. At the receiver's side, the corresponding layer applies the inverse of the transformation that has been applied at the source. As an example, if the Data link layer at the sender's side adds an error detection code to the frame, then at the receiver's side, the Data link layer verifies the error detection code and removes it from the frame before passing it to the next higher level, i.e. the Network layer.

Data transfer in OSI model

The 7-layer ISO reference model forms a framework for communication between the devices attached to the network. For different networks, the number of layers and their functions may vary. For example, the TCP/IP Internet protocol is organized into five layers. The X.25 Wide
Area Network protocol (the first public data network) provides connectivity to Public Switched
Telephone Network (PSTN) network and has three layers.

Network Devices

The cables are used to transmit data in the form of signals from one computer to another. But cables cannot transmit signals beyond a particular distance. Moreover there is a need to connect multiple computers and devices. A *concentrator* is a

device having two or more ports to which the computers and other devices can be connected.

A concentrator has two main functions:

(1) It amplifies the signal to restore the original strength of the signal.

(2) It provides an interface to connect multiple computers and devices in a network. Repeater, hub, switch, bridge, and gateway are examples of network connecting devices.

Two or more LANs using different protocols may not be able to communicate with the computers attached to their network. For example, a LAN connected using Ethernet may not be able to communicate with a LAN connected using Token Ring. Bridge, Router, and Gateway are devices used to interconnect LANs.

i.   Network Interface Card

A Network Interface Card (NIC) is a hardware device through which the computer connects to a network.

NIC is an expansion card, it can be either ISA or PCI, or can be on-board integrated on a chipset. NIC has an appropriate connector to connect the cable to it. NIC for different LAN are different (NIC for token ring is different from NIC for Ethernet).
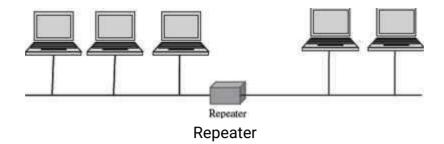

NIC card

NIC work at both the data link layer and physical layer of the OSI reference model

At the data link layer, NIC converts the data packets into data frames, adds the Media Access address (MAC address) to data frames. At the physical layer, it converts the data into signals and transmits it across the communication medium. The MAC address is a globally unique hardware number present on the NIC and is specified by the NIC manufacturer.

NIC depends upon the configuration of the computer, unlike hub or switches that perform independently.

ii.   Repeater

Repeaters are used to extend LAN. It has only two ports and can connect only two segments of a network. Multiple repeaters can be used to connect more segments. (Segment is

a logical section of the same network).

Repeater

Repeaters operate at the Physical layer of OSI reference model.

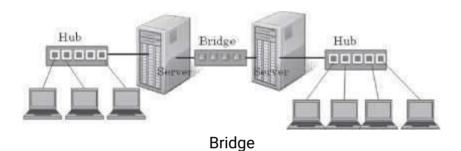They are useful when computers in a network are located far away from each other.

Repeaters amplify the signal so that the signal is as strong as the original signal. They can thus extend the reach of a network.

Repeaters cannot be used if multiple computers need to be interconnected or multiple segments need to be interconnected.

Repeaters cannot identify complete frames. Thus, in addition to the valid transmissions from one segment to another, repeater also propagates any electrical interference occurring on a segment to other segment.

iii.   Bridge

Bridge is used to connect two LAN segments like a repeater; it forwards complete and correct frames to the other segment. It does not forward any electrical interference signals to the other segment.
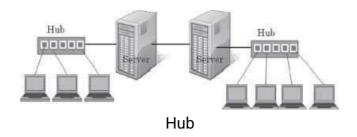

Bridge

Bridge forwards a copy of the frame to the other segment, only if necessary. If a frame is meant for a computer on the same segment, then bridge does not forward a copy of the frame to other segment.

Bridge connects networks that use different protocol at the Data Link Layer. The frame format of data in the two networks is different. The bridge converts the frame format before transmitting data from one network to another, with translation software included in the bridge.

Bridge is also used to divide a network into separate broadcast domains to reduce network traffic while maintaining connectivity between the computers.

iv.   Hub

It is like a repeater with multiple ports. But, hub does not amplify the incoming signal.

Hub operates at the Physical layer of OSI reference model, hence treats data as a signal.

Hub

Hubs are used to connect multiple segments of the same network.
Hubs are also used to connect computers to network that use Star topology.
The port on the hubs can also be used to connect another hub, switch, bridge or router.
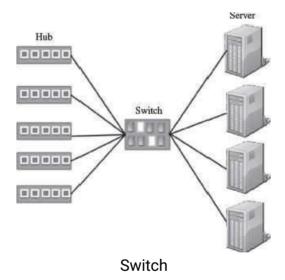Hubs increase the network traffic because they broadcast data to all the devices connected all the ports of the hub.
It is preferable to use a hub in a small LAN having about 8–10 computers connected to it.

v.   Switch
Like hub, switch also connects multiple computers in a network or different segments of the same network. A hub simulates a single segment that is shared by all computers attached to it (hub transmits the data to all computers attached to it). In a hub, at most two computers can interact with each other at a given point of time. However, in a switch each computer attached to a switch has a simulated LAN segment.
Switches work at the Data Link Layer of the OSI reference model. Hence, switches consider data as frames and not as signals.

Switch

A data frame contains the MAC address of the destination computer. A switch receives a signal as a data frame from a source computer on a port, checks the MAC address of the frame, forwards the frame to the port connected to the destination computer having the same MAC addresses, reconverts the frame back into signal and sends to the destination computer.
(Switching is a technique that reads the MAC address of the data frame and forwards the data to the appropriate port). Switches, thus, regenerate the signals.
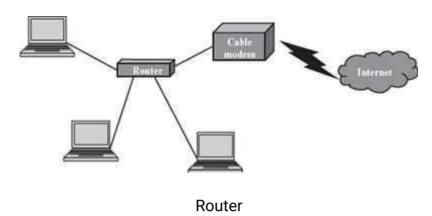Since a switch does not broadcast data, but sends the data from the source computer to the destination computer, a half of the computers attached to the switch can send data at the same time.
Switch is also referred to as a multi-port bridge. In general, bridges are used to extend the distance of the network, and switches are primarily used for their filtering capabilities to create a multiple and smaller virtual LAN (a LAN segment can be connected to each port of

the switch) from a single large LAN.

vi.   Router
Router is used to connect heterogeneous networks.

Router

    A router has a processor, memory, and I/O interface for each network to which it connects.
    A router connects networks that use different technologies, different media, and physical addressing schemes or frame formats.
    A router can connect two LANs, a LAN and a WAN, or two WANs.
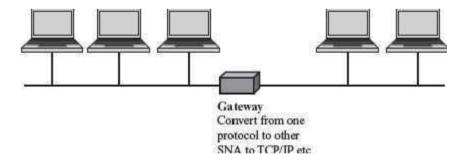   A router is used to interconnect the networks in the Internet.
    Router operates at the Network layer of the OSI model (layer 3).
    Physically, a router resembles a bridge, but is different from a bridge. A router determines which way is the shortest or fastest in a network, and routes packets accordingly. Since it works at the
Network layer, it moves packets based on the IP addresses etc. In contrast, a bridge connects two LANs almost permanently.

vii.   Gateway
Gateway is a generic term used to represent devices that connect two dissimilar networks.

Gateway

    A gateway at the transport layer converts protocols among communications networks. It can accept a packet formatted for one protocol and convert it to a packet formatted for another protocol, before forwarding it. An application gateway can translate messages from one format to the other.
    A gateway can be implemented in hardware, software, or in both hardware and software. Generally, gateway is implemented by software installed within a router.
The network connecting devices—repeater and hub operate at the physical layer, bridge and switch operate at the data link layer, and the router operates at the

network layer of the OSI model.

9.7 WIRELESS NETWORKING

Wireless technology, as the name suggests, is used to establish a wire-free connection or communication between two or more devices. In contrast to the wired technology where data is encoded as electric current and signals travel through wires, in wireless technology data is encoded on electromagnetic waves that travel through air. The wireless technology is used for broadcasting in radio and television communication, for communication using mobile phones and pagers, for connecting components of computers using Bluetooth technology, for Internet connection using Wi-Fi, Wireless LAN, PDA, and in remote controls for television, doors etc.

Wireless network is a computer network connected wirelessly. The communication is done through a wireless media like radio waves, infrared or Bluetooth.

The wireless networks have two main components—the wireless access points that include the transmitter along with the area it can cover, and the wireless clients like mobile handsets, laptops with Ethernet cards etc.

The access point receives data frames from the computers attached to it wirelessly, checks the frames, and transmits them to their destination. The coverage area of a transmitter depends on the output power of the transmitter, its location, and the frequency used to transmit the data.
Higher frequencies require a clear line of sight as compared to lower frequencies.

The speed of wireless connection is determined by the distance of the wireless client device from the access point, the obstruction-free path (walls, trees etc.), interference, and the number of users using the network at a given time.

Wireless networks can be divided into three categories based on their use:
- *Bluetooth technology* to connect the different components of the computer in a room, a small office or home.
- *Wireless LAN* is used to connect computers and devices wirelessly in a LAN, for example, different computers or devices in an office or campus.
- *Wireless WAN* is used to connect wide area systems, for example access to Internet via mobile devices like cell phone, PDAs and laptops.

i.   Bluetooth Technology

The different components of the computer like the keyboard, printer, monitor etc., are connected to the computer case via wires. Bluetooth technology is used to connect the different components wirelessly. A printer placed in a room may be connected to a computer placed in a different room using Bluetooth technology. Using Bluetooth does away with the wires required to connect the components to the computer and allows portability of components within a small area lying within the Bluetooth range.
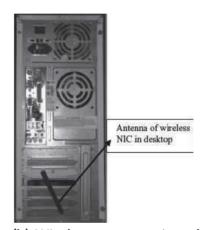

Bluetooth

Wireless LAN

Wireless LAN has some benefits over the wired LANs. In wireless LAN, there is flexibility to move the computers and devices within the network. It can connect computers where cabling is not possible. It is easy to expand by using an access point. Since no physical medium is required, wireless LANs are easy to install. Since data is transmitted using radio or infrared waves, there is no attenuation or distortion of the signal due to electromagnetic interference. Wireless LANs are used at home to connect devices on different floors or to set up a home network, to provide connectivity in public places like airports, railway stations, college campus, and hotels etc., where traveling users can access the network. Wireless LANs can also be connected to a WAN thus providing access to Internet to the user. IEEE 802.11 is a standard for wireless LAN.
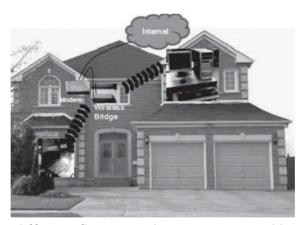

(a) Wireless Ethernet bridge   (b) Wireless antenna in a desktop

Computers at different floors in a house connected by wireless LAN

Wireless WAN

The radio network used for cellular telephone is an example of wireless WAN. Wireless WANs allow the users to access the Internet via their mobile devices. This provides flexibility to the user to access the Internet from any location where wireless connectivity exists.

Wireless WAN

Almost all wireless networks are connected to the wired network at the back-end to provide access to Internet. Wireless networks also offer many challenges, like, the compatibility among different standards promoted by different companies, congested networks in case of low bandwidth, the high infrastructure and service cost, data security, battery storage capability of wireless device, and health risk.

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